Karlsruher Institut für Technologie

Institut für
Thermische Strömungsmaschinen
Prof. Dr.-Ing. Hans-Jörg Bauer, Ord.

ITS

Winter Term 2022/2023
28.10.2021 - 17.02.2023
Term projects: 02.12.22 - 17.02.23

Data Driven Engineering 1
Machine Learning for Dynamical Systems

Basics

0. Introduction to DDE Lecture & $(KI)^2T$ Project Finals 28.10.22

1. Basics: An Ode to Learning 04.11.22
   - 1.1. The Flow of the Lecture
   - 1.2. A holistic view on AI and ML
   - 1.3. Data-Driven Dynamical Systems
   - 1.4. Machine Learning: Overview, Means and Goals
   - 1.5. Contemporary Examples

Fundamentals

2. Analysis of Static Datasets I: Regression and Classification 11.11.22
   - 2.1. Supervised ML Landscape
   - 2.2. Regression 11.11.22
     - 2.2.1. Lasso
     - 2.2.2. Elastic Net
     - 2.2.3. SVM
     - 2.2.4. Bayesian Ridge Regression
   - 2.3. Classification 18.11.22
     - 2.3.1. Logistic Regression
     - 2.3.2. Gradient Decent
     - 2.3.3. Random Forests
     - 2.3.4. Boosting
3. Analysis of Static Datasets II: Clustering and Dimensionality Reduction 25.11.22
   - 3.1. Unsupervised ML
   - 3.2. Clustering
     - 3.2.1. K-Means
     - 3.2.2. Hierarchical Clustering
     - 3.2.3. DBSCAN
   - 3.3. Dimensionality Reduction 02.12.22
     - 3.3.1. Sparsity and Compressed Sensing
     - 3.3.2. Linear projection

3.3.2.1. SVD, PCA
3.3.3. Manifold learning
3.3.3.1. Isometric mapping, MDS, LLE
3.3.4. Dictionary Learning
3.3.5. Independent Component Analysis

ML for Dynamical Systems

4.	Deep Learning for Dynamical Systems	09.12.22
	4.1. The Perceptron and Building DNN	
	4.2. Activation Functions	
	4.3. Training NN: Backpropagation, Learning Rate, Regularization	
5.	Sequence Modeling	23.12.22
	5.1. Statistical models	
	5.2. Neural Networks for Dynamical Systems	13.01.23
	5.3. Recurrent Neural Networks	
	5.4. Gated Cells: Long Short-Term Memory (LSTM)	
6.	Generative Modeling	20.01.23
	6.1. Latent Variables and Sparsity	
	6.2. Representation Learning	
	6.3. Autoencoders	
	6.4. Variational Autoencoders (VAEs)	27.01.23
	6.5. Generative Adversarial Network (GAN)	03.02.23
7.	Machine Learning Control	10.02.23
	7.1. Data-Driven Dynamical Systems	
	7.2. Model Reduction and Linear System Identification	
	7.3. Sparse Identification of Nonlinear Dynamics and Control	
8.	Emerging Concepts and the Outlook	17.02.23
9.	Q&A Session / Open Discussions	24.02.23

Note 1: The given dates indicate the starting date of a given topic we will work on. Some concepts will be covered in 2 lecture sessions.

Note 2: Q&A session is not an official lecture. I will be available in class for your questions, particularly for the ongoing individual projects.